Annual Report

RELATIONSHIPS BETWEEN MOISTURE TRANSPORT AND PRECIPITATION DURING THE NORTH AMERICAN MONSOON

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PROJECT DURATION
October 2002 - September 2005

ANNUAL REPORT PERIOD
October 2003-September 2004

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INTRODUCTION
The work summarized below has been carried out over the past year (October 2003-September 2004). Activities were focused in two general areas: (i) development of radiosonde archives for the validation of wind and moisture analyses produced by NCEP and (ii) studies of relationships between Gulf of California moisture surges and tropical cyclones in southwestern North America. Our specific research activities included:

(1) Validate mean wind, humidity and moisture transport fields in NCEP global and regional analyses in the NAME domain.

(2) Estimate components of the moisture budget in the core North American monsoon region.

(3) Diagnostic studies of relationships between moisture transport and precipitation in the core North American monsoon region.

Overall project goals and methodology are discussed in the original proposal and in various publications listed below.

PROPOSED WORK AND ACCOMPLISHMENTS (October 2003-September 2004)

Accomplishments for the following 8 tasks are combined in the discussion below:

Task 1.1 Build station climatologies of wind, moisture transport and precipitation.
Task 1.2 Determine the bias in the historical data.
Task 1.3 Compute uncertainties in the NCEP/NCAR Global Reanalysis and the NCEP Regional Reanalyses.
Task 1.4 Compute uncertainties in the NCEP Eta Model Data Assimilation System (EDAS).
Task 2.1. Estimate the daily moisture budget for Mexico from observations.
Task 2.2 Examine diurnal variations of wind and convergence in the core monsoon region.
Task 2.3 Estimate uncertainty in the moisture budget in the EDAS using MOLTS and gridded fields.
Task 2.4 Estimate uncertainty in the moisture budget in the NCEP Regional Reanalysis.

Five different archives of radiosonde data were unpacked, processed, analyzed and written in common formats, and their deficiencies have been studied; the five archives are NCDC CDROM archive (1948-1998), Creighton University / Mexican Weather Service CDROM archive 1 (1948-1998), archive 2 (1999-2000) and archive 3 (2001-2002), and FSL data (January-July 2003). Daily time series of humidity, wind components and vapor flux components have been put together by blending the best available combination of data for all stations in the North American Monsoon domain (Fig. 1). These time series were produced for every observation time for 1948-2003. Station climatologies for water budget related parameters (precipitable water and components of vertically integrated vapor flux) were built (Fig. 2).

Daily water budget estimates over Mexico were computed for the period January 1973 – July 2003. The annual cycle of the *(P-E)* difference is presented in Fig. 3. It reveals some unrealistic features, such as a decrease of vapor flux convergence from June to July and a sharp drop in convergence from August to September followed by an increase from September to October. These features of the water budget over the NAM domain are likely due to several factors:

(i) inconsistent wind records in historical radiosonde datasets,
(ii) incomplete records for significant levels after the mid-1990's;
(iii) large distances between stations;
(iv) little or no overlap between station records; and
(v) variations in observation times.

Regional reanalysis data for the period 1978-2002 were processed in preparation for computation of the large-scale water budget over the NAM domain. The archive, which has recently been completed, will be used to examine diurnal variations in wind and convergence in the core monsoon region. EDAS MOLTS have been routinely saved in real time since 1995. Regional MOLTS have been extracted from the archive. Comparison of EDAS-generated moisture fluxes and humidity with radiosonde-observed values will be performed after re-running the radiosonde archive for the late 1990's.

Accomplishments for the following 4 tasks are combined in the discussion below:

Task 3.1 Examine climatological aspects of Gulf of California moisture surges.
Task 3.2 Determine interannual relationships between moisture surges and precipitation
Task 3.3 Examine spatial-temporal relationships between surge events, atmospheric circulation and precipitation.
Task 3.4 Publish the results of research carried out under Task 3.

We acquired, formatted and processed an archive of hourly surface station data for the US and Mexico (1977-present) in preparation for several studies of GOC surge / precipitation relationships.

Relationships between Gulf of California moisture surges and precipitation in southwestern North America were examined using the archive of surface observations (dewpoint, wind speed, wind direction) and the US_Mexico observed precipitation database (Higgins et al. 2004). Gulf of California surges were related to tropical easterly waves and midlatitude westerly waves. A key result of the study is that the response to surges in Arizona / New Mexico strongly depends on the strength and location of the monsoon anticyclone (Fig. 4).

Relationships between Gulf of California moisture surges and tropical cyclones (TC's) in the eastern Pacific basin have been examined in a follow on study (Higgins and Shi 2004). It is shown that the response to a Gulf surge in the southwestern U.S. and northwestern Mexico is strongly discriminated by the presence or absence of TC's. Surges that are related to TC's tend to be associated with much stronger and deeper low-level southerly flow, deeper plumes of tropical moisture, and wetter conditions over the core monsoon region than surges that are unrelated to TC's. The response to the surge is also strongly influenced by the proximity of the TC to the GOC region (Fig. 5). Surges that are directly related to TC's that track towards the GOC are associated with a much stronger response on average than surges that are indirectly related to TC's that track away from the GOC (Fig. 6).

The extent to which these relationships are influenced by the ENSO cycle has also been investigated. Because El Nino (La Nina) is associated with a significant increase (decrease) in TC activity in the eastern tropical Pacific, there is a tendency for the surge-TC relationships to be more pronounced during El Nino and weaker during La Nina events.

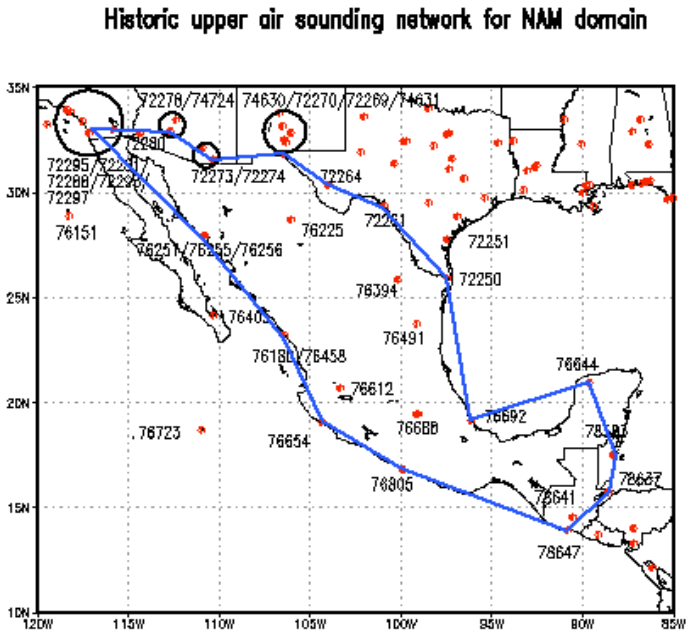

Figure 1. Historical upper air sounding network over North American monsoon domain

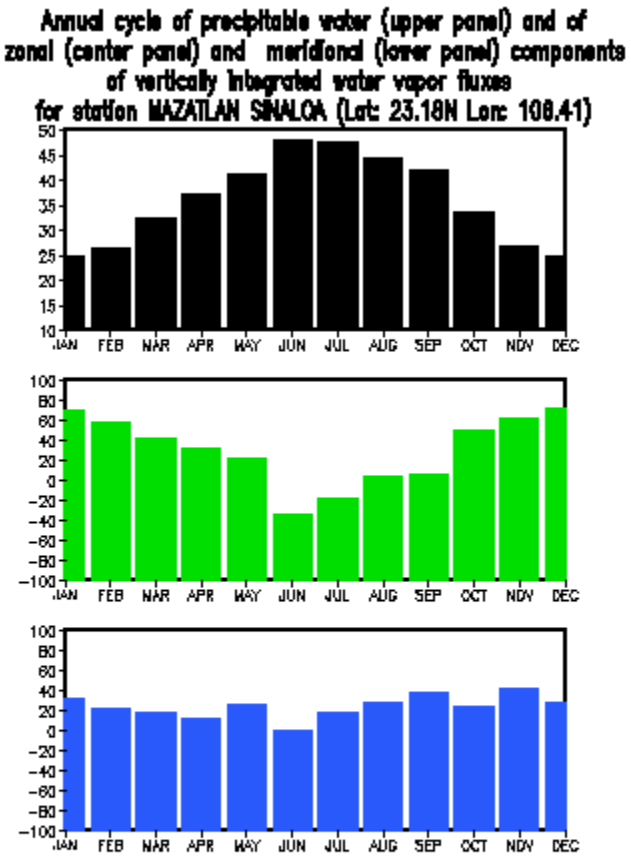

Figure 2. Annual cycles of precipitable water and water vapor fluxes for station WMO 76458 (Mazatlan, Sinaloa)

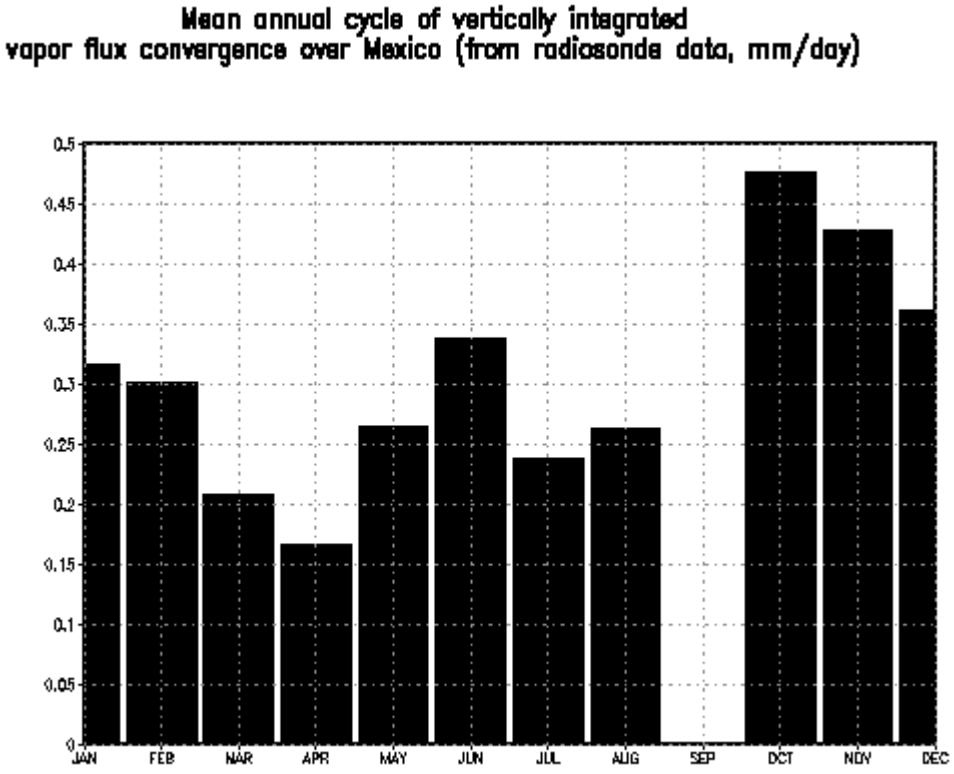

Fig. 3. Annual cycle of *(P-E)* over Mexico as estimated from daily radiosonde observations.

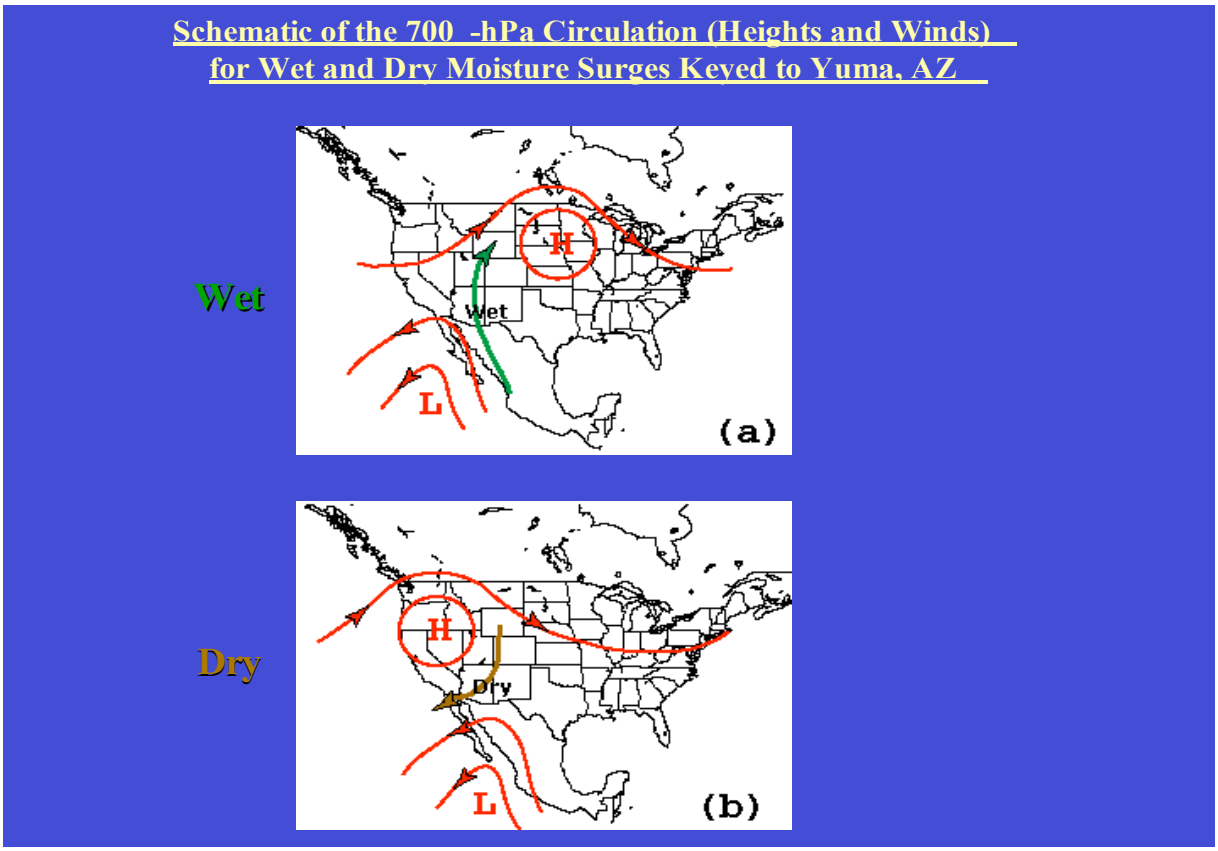

Figure 4. Schematic of the typical 700-hPa circulation features (heights and winds) that accompany (a) wet and (b) dry surges keyed to Yuma, AZ.

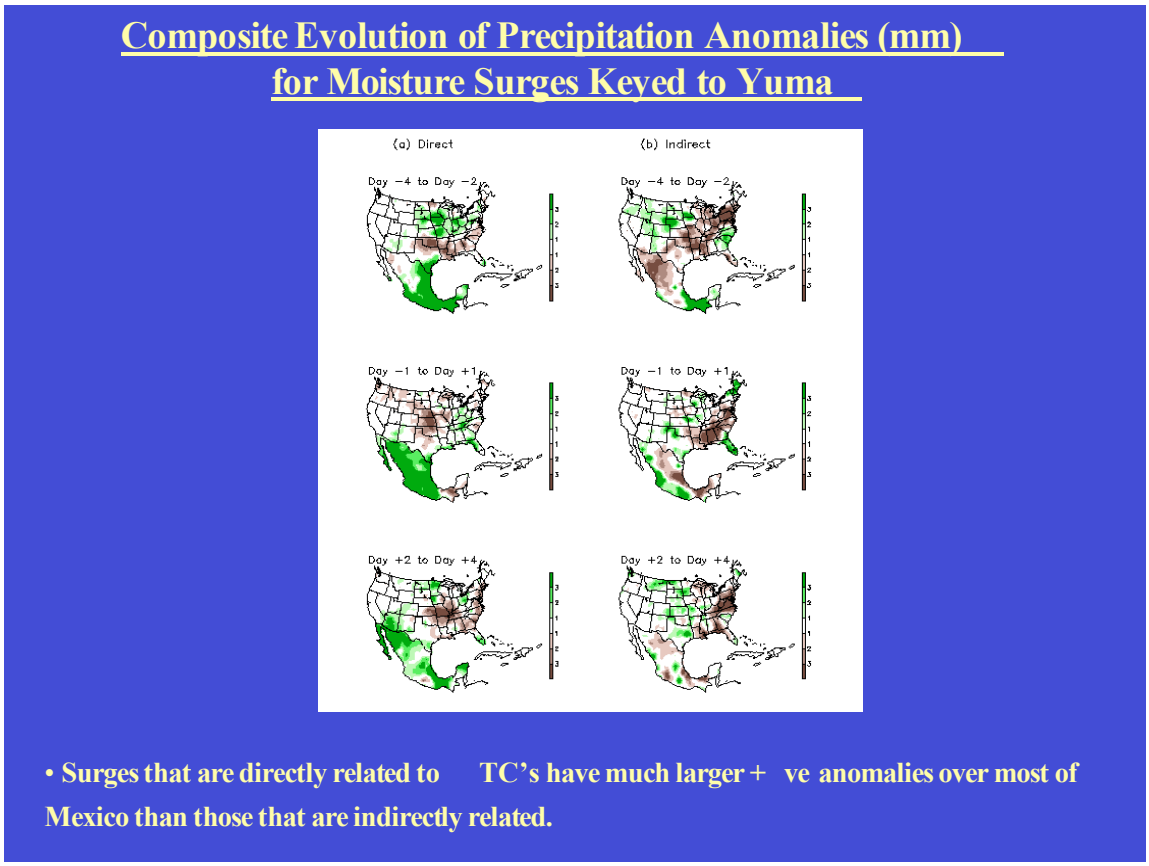

Figure 5. Composite evolution of accumulated precipitation anomalies (mm) for TC-related moisture surges keyed to Yuma, AZ. (a) Direct and (b) Indirect. Day 0 is the onset date of the surges at Yuma. The accumulation period relative to onset is indicated on each panel. The contour interval is 1 mm day^{-1}, the zero contour is omitted for clarity, and values greater than 1 mm day^{-1} (less than -1 mm day^{-1}) are shaded dark (light).

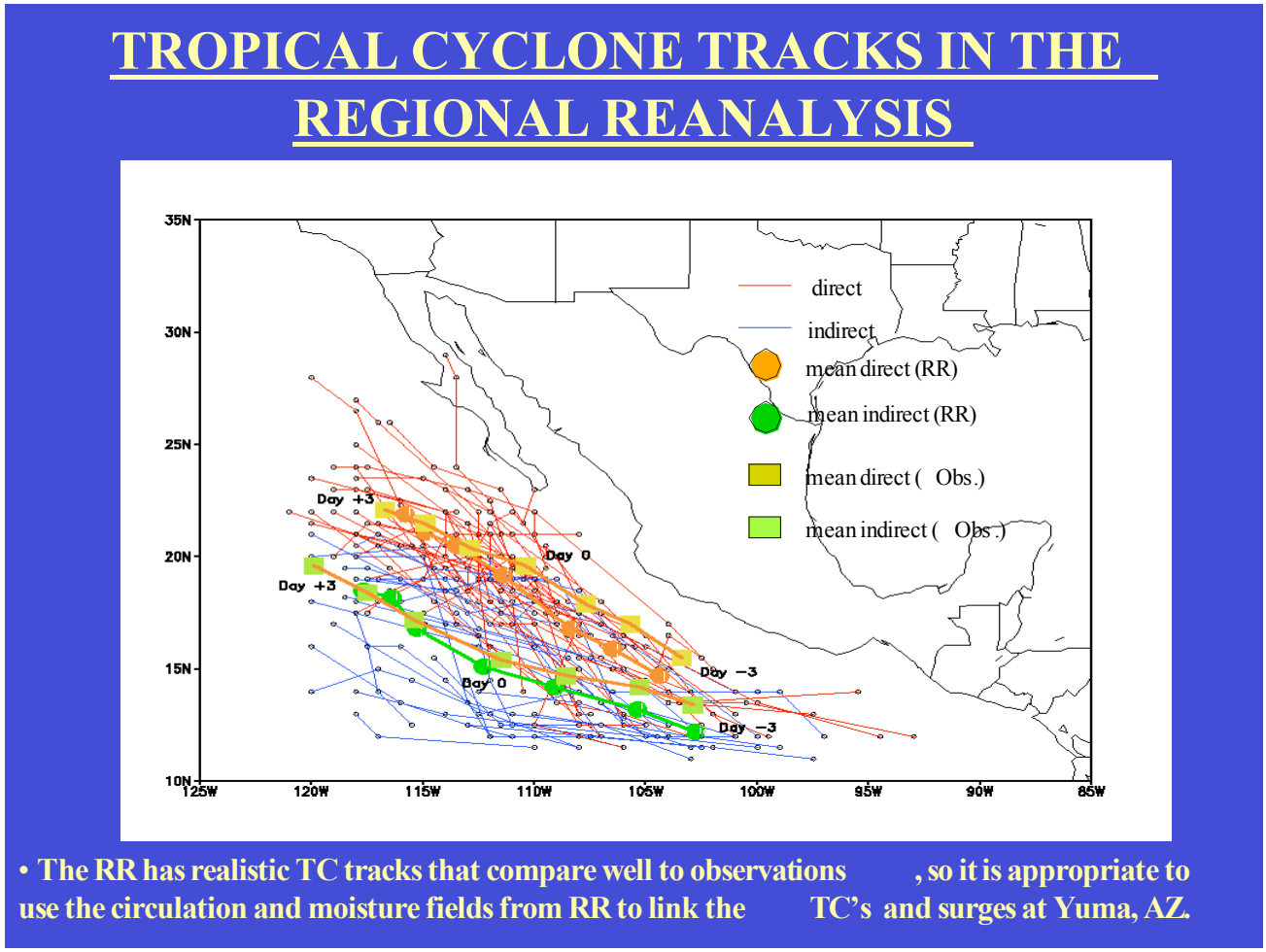

Figure 6. Tropical Cyclone (TC) tracks within 3 days of Yuma surges from the NCEP Regional Reanalysis. Cases that are directly (indirectly) related to Yuma surges are indicated by dark (light) lines. The mean tracks from the Regional Reanalysis and from observations for both the direct and the indirect cases are also shown. The observed tracks are from the NHC HURDAT dataset as described in the text. The day relative to onset is indicated along the mean tracks.

PUBLICATIONS AND PRESENTATIONS:

Journal Articles (peer-reviewed):

Higgins, R. W., W. Shi and C. Hain, 2004: Relationships between Gulf of California moisture surges and precipitation in the southwestern United States. *J. Climate,* **17***,* 2983-2997

Higgins**,** R. W., and W. Shi, 2004: Relationships between Gulf of California moisture surges and tropical cyclones in the Eastern Pacific basin. *J. Climate*, (submitted)

Conference Presentations / Preprints:

Higgins, R. W., and W. Shi, 2004: Relationships between Gulf of California moisture surges and tropical cyclones in the eastern Pacific basin. 29th Annual Climate Diagnostics and Prediction Workshop, Madison, WI, Oct 18-22 (Poster)

Higgins, R.W., W. Shi and C. Hain, 2004: Relationships between Gulf of California Moisture Surges and Precipitation in the Southwestern United States. International CLIVAR Conference, Baltimore, MD, Jun. 21-25 (Poster)

Higgins, R.W., W. Shi and C. Hain, 2003: Relationships between Gulf of California Moisture Surges and Precipitation in the Southwestern United States. 28th Annual Climate Diagnostics and Prediction Workshop, Reno, NV, Oct 20-24

Higgins, R. W., and the NAME SWG, 2003: The North American Monsoon Experiment (NAME): Status and Plans. 28th Annual Climate Diagnostics and Prediction Workshop, Reno, NV, Oct 20-24

Yarosh, E., R. W. Higgins and W. Shi, 2003: Climate of atmospheric water budget over North American monsoon area as seen from radiosonde observations.. 28th Annual Climate Diagnostics and Prediction Workshop, Reno, NV, Oct 20-24

Yarosh, E., R. W. Higgins and W. Shi, 2004: Long-term atmospheric water budget parameters over NAME domain from radiosonde observations. 15th Symposium on Global Change and Climate Variations, Long Beach, CA, Jan 11-15

Yarosh, E., R. W. Higgins and W. Shi, 2004: Climate of atmospheric water budget over North American Monsoon area as seen from radiosonde observations. International CLIVAR Conference, Baltimore, MD, Jun. 21-25

Higgins, R. W., 2003: Overview of the North American Monsoon Experiment (NAME). AMS Symposium on Observing and Understanding the Variability of Water in Weather and Climate, 83rd AMS Annual Meeting, Long Beach, CA,, (Feb 2003)

Meetings Attended:
Seattle Winter Season Weather Workshop briefings (Oct. 03)
28th Climate Diagnostics and Prediction Workshop (Reno, NV; Oct. 03)
NCEP Seminar: NAME: Status and Plans (Oct. 3, 2003)
NAME Special Session (UGM) (Puerto Vallarta, MX; Nov. 03)
NAME SWG-5 (Puerto Vallarta, MX; Nov. 03)
CLIVAR Pacific and Atlantic Proposal Panel (Silver Spring, MD; Nov. 03)
NWS HQ Briefing on NAME Soundings (Washington DC; Dec 03)
NAME EOP/IOP Planning Meeting (Boulder, Co, Mar 04)
7th WCRP CLIVAR/VAMOS Panel Meeting (Guayaquil, Ecuador; Mar 04)
NAME Operations Review / Forecaster Orientation / 6th NAME SWG Meetings (Tucson AZ; Apr. 04)
COMET Course (North American Monsoon) (Boulder, CO, Apr. 04)
International CLIVAR Conference (Baltimore, MD, Jun. 04)
Pan American Panel Meeting (Baltimore, MD, Jun. 04)
CLIVAR SSG Meeting (Baltimore, MD, Jun. 04)
NAME Forecast Operations Center (Tucson, AZ, Jul 04)
NAME Forecast Operations Center (Tucson, AZ, Aug. 04)
GAPP PI Meeting (Boulder, CO, Aug 04)
GAPP SAG Meeting (Boulder, CO, Aug 04)
29th CDPW (Madison, WI, Oct 04)

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